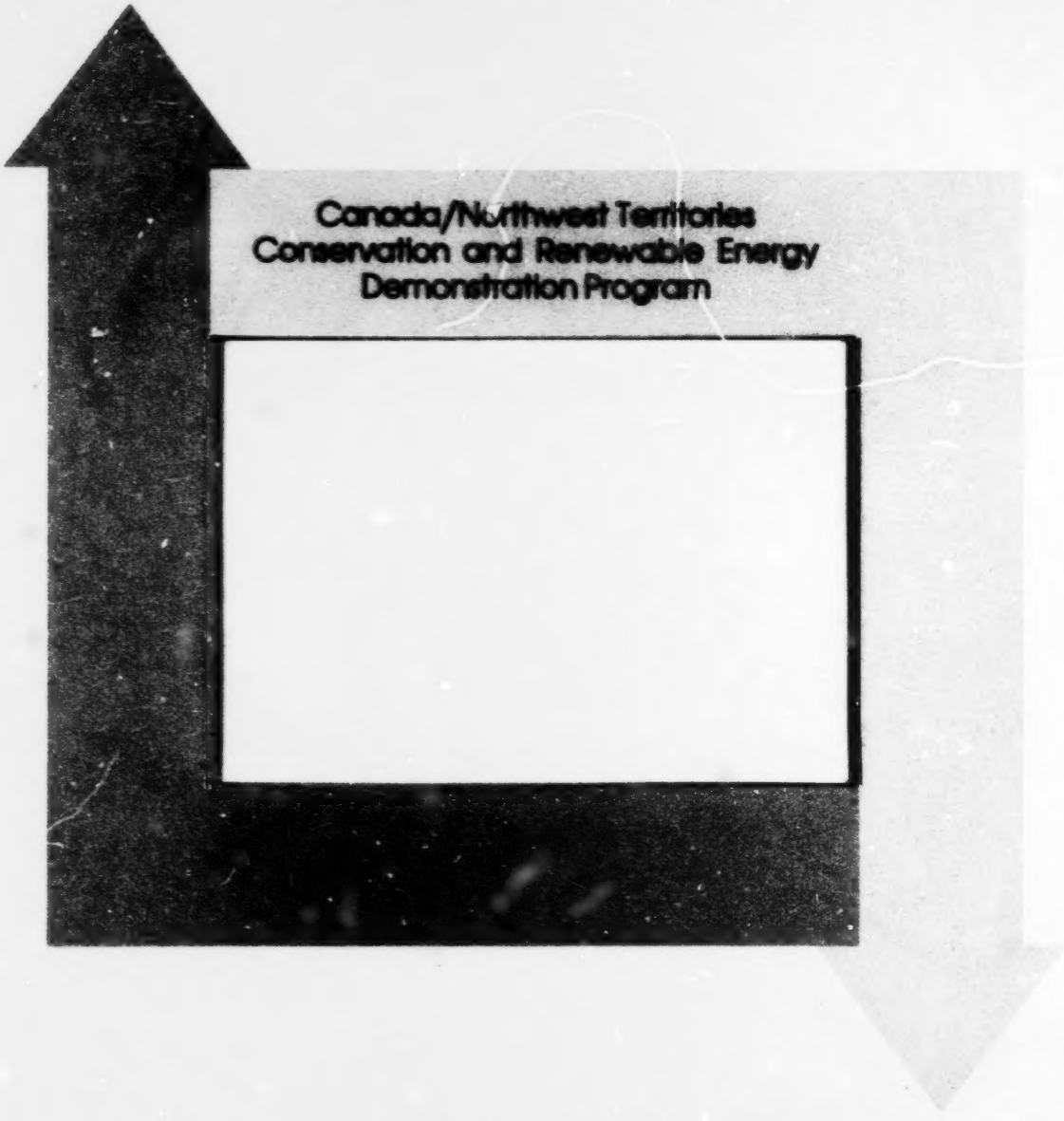
N.W.T.
- 9



Energy, Mines and Resources Canada

Energie, Mines et Ressources Canada

Northwest Territories Public Works

MANECON PARTNERSHIP
MANAGEMENT & ECONOMIC CONSULTANTS

Energy, Mines and Resourses Canada
&
Energy Conservation Division
Department of Public Works
Government of the Northwest Territories

WIND ENERGY
for
REMOTE LIVING

THIS PROJECT WAS CONVENED BY
CANADA/NORTHWEST TERRITORIES
CONSERVATION AND RENEWABLE ENERGY
DEMONSTRATION PROGRAM

MAY 1983

415, REVILLON BUILDING, 10201 - 104 STREET, EDMONTON, ALBERTA T5J 1B2
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CANADA/NWT CONSERVATION
AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of N.W.T. and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed March 24, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Cost-shared by the territorial and federal governments, the program has a total budget of $3.3 million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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PROJECT SUMMARY

The Canada/NWT Conservation and Renewable Energy Demonstration Agreement program provided a grant of $5,100.00 in October 1981 to Roland and Anne Brandt to assist with the demonstration of the use of wind energy for remote domestic living. The Brandts have installed a small wind power turbine and generation system and operate the system at their residence at Prelude Lake, 40 km NE of Yellowknife, N.W.T. The system consists of a 3 kw wind generator, 30 m mast, 5.6 kwh battery storage, and simple electrical controls. The energy is used to provide domestic lighting and operate other small occasional electric loads in the residence.

This report is prepared on behalf of the NWT CREDA office by Manecon Consulting Partnership and documents the experiences gained by the project, the costs and benefits, and its suitability as a demonstration project.

The assignment was conducted by visiting the project site, examining the operation and equipment, through discussions with Roland Brandt, and through review of the project files of the NWT CREDDA office.

The residence presently is supplied with sufficient wind energy to meet the lighting needs, as expected. The operation of the system has been technically successful and proven to be a reliable source of energy. The degree of progress seen and the achievements made are plainly as a result of the commendable ingenuity of the owner to assemble the materials and capital equipment on a shoe-string budget, integrate them into a workable system, and commit the time and effort to make the project a technical success.

The economic viability of the project is questionable and is dependent on the free labour and scrounging ability of the proponent. The actual capital costs incurred were a small portion of the true off the shelf costs for similiar new equipment and for installation services. To pursue a project in this present form the proponent must adopt the project as a hobby or vocation, and make an intellectual commitment to understand the technology and the operation of the wind energy generation system.

RESUME DU PROJECT

Le programme conjoint du Canada et des T.N.O. de démonstration pratique de la conservation et de l'énergie renouvelable (CREDA*), a accordé une subvention de $5100.00 en Octobre 1981 à Roland et Anne Brandt pour aider à la démonstration de l'usage domestique de l'énergie éolienne dans les endroits isolés. Les Brandt ont installé une turbine éolienne et un générateur électrique qu'ils opèrent à leur résidence du lac Prelude, 40 kilomètres au nord-est de Yellowknife, T.N.O.

Le système consiste d'une turbine éolienne de 3 kw, d'un pylône de 30 mètres, d'un accumulateur à batteries de 5.6 kwh et de contrôles électriques simples. L'énergie sert à fournir l'éclairage et à répondre à d'autres demandes occasionnelles minimes d'électricité dans la maison.

Ce rapport a ete rédigé au nom du bureau de CREDA des T.N.O. par l'Association d'Ingénieurs-conseils Manecon (Manecon Consulting Partnership) et documente l'expérience pratique acquise par le biais de ce projet, les coûts et les avantages, et sa praticabilité comme projet de démonstration.

Cette tache fut accomplie par des visites à la location du projet, en examinant le fonctionnement et l'équipement, à travers des discussions aver Roland Brandt et à travers la révision des dossiers du projet au bureau de CREDA des T.N.O.

Tel qu'attendu, la maison est présentement approvisionnée suffisamment en énergie éolienne pour subvenir aux besoins de l'éclairage. Le système s'est demontré une source sûre d'énergie et son fonctionnement a été une réussite technique. Le niveau des progrès et des accomplissements atteints est clairment le fait de la très grande ingénio-

*CREDA: Conservation and Renewable Energy Demonstration Agreement

sité du propriétaire à rassembler les matériaux et les fonds pour l'équipement, et à les organiser en un système réalisable. De plus, il a donné de son temps et de son travail pour assurer la réussite technique du projet.

La rentabilité du projet est douteuse et dépend de la main d'oeuvre gratuite du participant et de son habileté à économiser. Les dépenses encourues n'ont été qu'une petite partie du prix courant de l'équipement neuf similaire et des frais d'installation. Pour poursuivre un projet dans cette forme présente, le participant doit considérer le projet comme un loisir ou une vocation, et doit prendre l'engagement intellectuel nécessaire, afin de comprendre la technologie et l'opération de ce systeme d'exploitation de l'énergie éolienne.

1.0 CONCLUSIONS

The conclusions reached as a result of this assignment are listed here. More detailed discussion of these points is found in subsequent sections.

1. The project has successfully demonstrated that wind energy can provide a contribution to the energy needs of a remote residence, and that the technology, obligations and constraints created by its use can be integrated into the family lifestyle.

2. The economic viability of the system is strongly dependent on the enterprising abilities of the owner, his commitment to the technology and willingness to devote free time and labour to ensure its success.

3. A large portion of the economic benefits of this system over a diesel electric generation source can be attributed to the availability of an energy storage medium. The addition of a wind generator to a diesel generator system equipped with adequate battery storage, to substitute for the diesel unit, provides much smaller cost savings than those created by batching the diesel energy production into brief periods, storing the energy, and consuming the energy over an extended time.

4. The particular system under review has not yet arrived at a final form. Due to personal financing constraints work has yet to be done to expand the battery stored energy capacity and improve on the electrical control and switching circuitry.

5. The project has not spawned any perceivable interest in the adoption of wind energy as a supplement to domestic or commercial energy needs.

6. The ability of this project to serve as an effective demonstration, sort out technical deficiencies, and gather significant public attention has been curtailed by the lack of sufficient financial support.

7. Roland Brandt has undertaken this project with determination and dedication to the technology. He has used the grant funds in a frugal and careful manner.

8. The CREDA grant given has been a very important factor in the progress of this project. The project may not have proceeded without the financial support given.

1.0 CONCLUSIONS

Les conclusions atteintes résultant de cette entreprise, sont inscrites ci-dessous. Dans les sections subséquentes se trouve une discussion plus détaillée de chacun de ces points.

1. Le projet a demontré avec succès que l'énergie éolienne peut fournir une contribution aux besoins énergétiques d'une maison dans un endroit isolé; et que la technologie, les obligations et les contraintes créées par son utilisation peuvent être intégrées au style de vie familial.

2. La rentabilité du système depend fortement des aptitudes d'entrepreneur du propriétaire, de son intérêt dans la technologie et de son désir de donner de son temps et de son travail pour en assurer le bon développement.

3. Une grande partie des avantages économiques de ce système face à une source de production électrique à l'huile lourde peuvent être attribués à la disponibilité d'un moyen d'accumulation de l'énergie. L'addition d'une turbine éolienne à un système de générateur diesel équipé d'une réserve de batteries adéquate, laquelle turbine peut remplacer l'élément diesel, produit des économies beaucoup moins substantielles que celles obtenues en divisant la production diesel de l'énergie en courtes périodes, emmagasinant l'énergie et la consommant sur une période de temps prolongée.

4. Le système particulier sous étude n'a pas encore atteint sa forme finale. En raison de contraintes financières personnelles, il y a encore beaucoup de travail à faire pour développer la capacité d'accumulation de l'énergie par les batteries, et pour améliorer les contrôles électriques et le circuit des commutateurs.

6. L'habileté de ce projet à faire une démonstration efficace, à identifier les défauts techniques, et à susciter signigicativement l'attention publique, a été restrainte par un support financier insuffisant.

7. Roland Brandt a entrepris ce projet avec détermination et avec enthousiasme pour la technologie. Il a utilisé les fonds de la subvention d'une manière économe et prudente.

8. La subvention que CREDA a accordée a été un facteur très important pour l'avancement du projet. Ce projet n'aurait possiblement pas été mis en marche sans ce support financier.

2.0 TECHNICAL DESCRIPTION

The wind energy generation system presently installed at the Brandt residence at Prelude Lake consists of the following elements:

i) a Wellington Windpower Model "Black" packaged wind generator

ii) a 100 ft. guyed wind generator tower

iii) a 50-65 amp/hr. nickel cadmium battery array for energy storage

iv) a simple control panel

The wind generator consists of a 14 ft. diameter three wooden blade fixed pitch rotor assembly, a 9.8 gear box speed increaser, a permanent magnet D.C. generator, and an azimuth slip ring assembly.

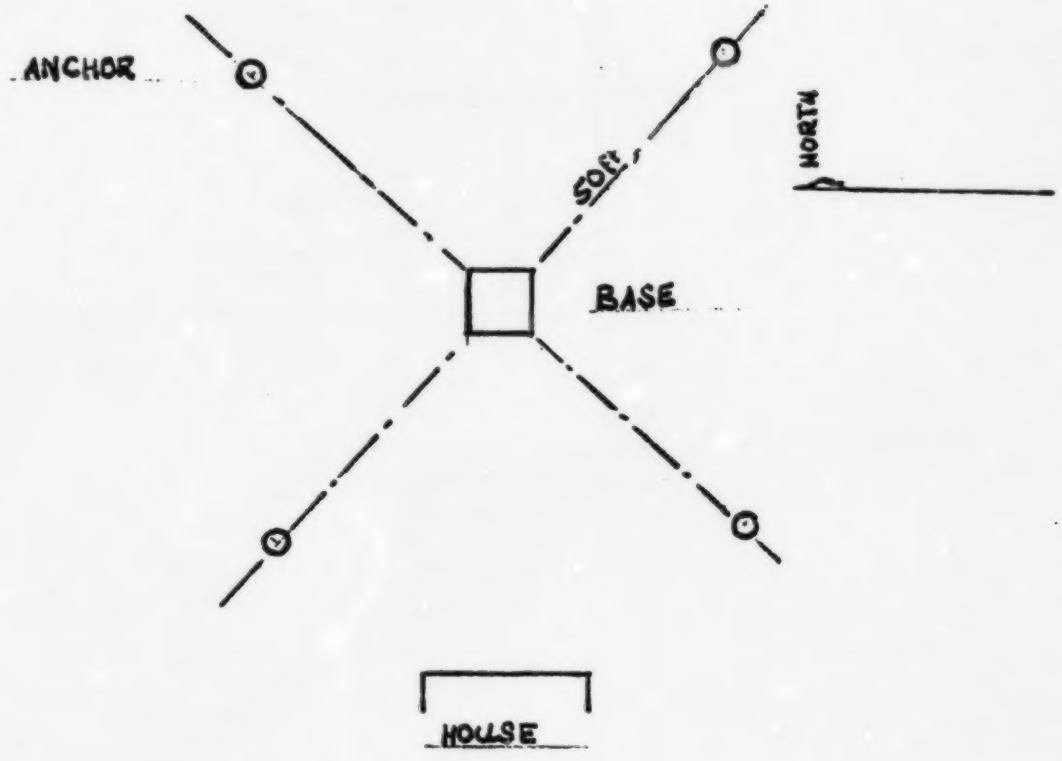
The rotor generator set is rated to produce 3 kw of power from a 22 mph (35 km/hr) incident wind. The starting threshold for the unit is approximately 15 km/hr but is a function of the temperature of the gear box lube oil.

The gear box speed changer is apparently a spur gear fitted unit, lubricated in this application with aviation instrument oil by Roland Brandt to improve the cold weather starting characteristics. Power created by the generator is transferred by two line No. 6 conductor through a slip ring assembly to a control panel. The slip rings assembly permits power transfer to the stationary tower while the generator set is free to rotate in azimuth to face the prevailing wind at any given time.

The guyed tower is constructed of angle iron on four edges, cross braced over the entire length with a diagonal lattice of steel rod. The cross section of the tower is 18" x 18" square. Anchors and a foundation for the tower are made from 45 gallon drums filled with concrete and buried in the ground. The tower is anchored at four ground points with steel cables running from each anchor to three elevations of the tower. Sketches of the tower installation drawn by Roland Brandt, are presented on the following pages.

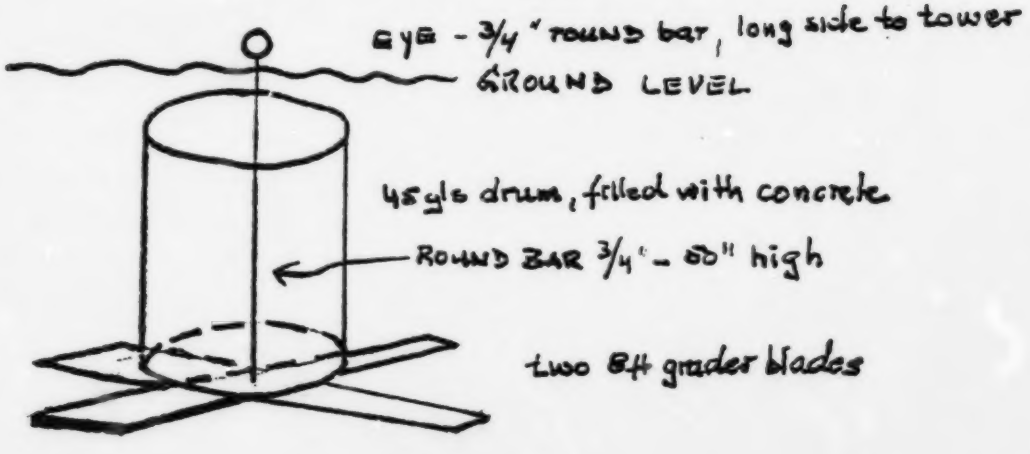
DRAWING I

Lay Out



DRAWING II

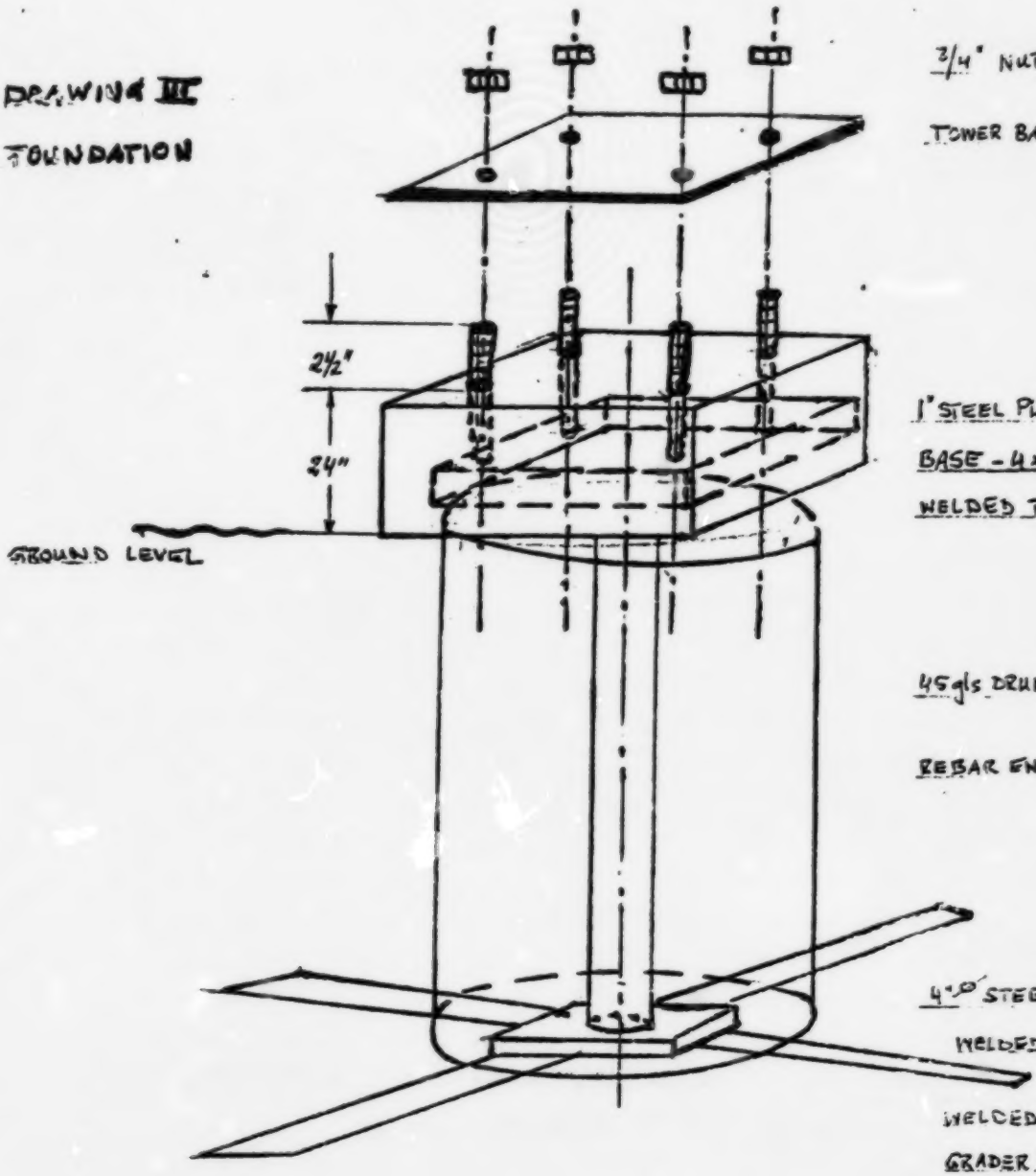
4 GUY ANCHORS


EYE - 3/4" round bar, long side to tower
GROUND LEVEL
45 gls drum, filled with concrete
ROUND BAR 3/4" - 60" high
two 8ft grader blades

ROUND BAR, BLADES & EYE ARE WELDED

DRAWING III

FOUNDATION



¾" NUTS

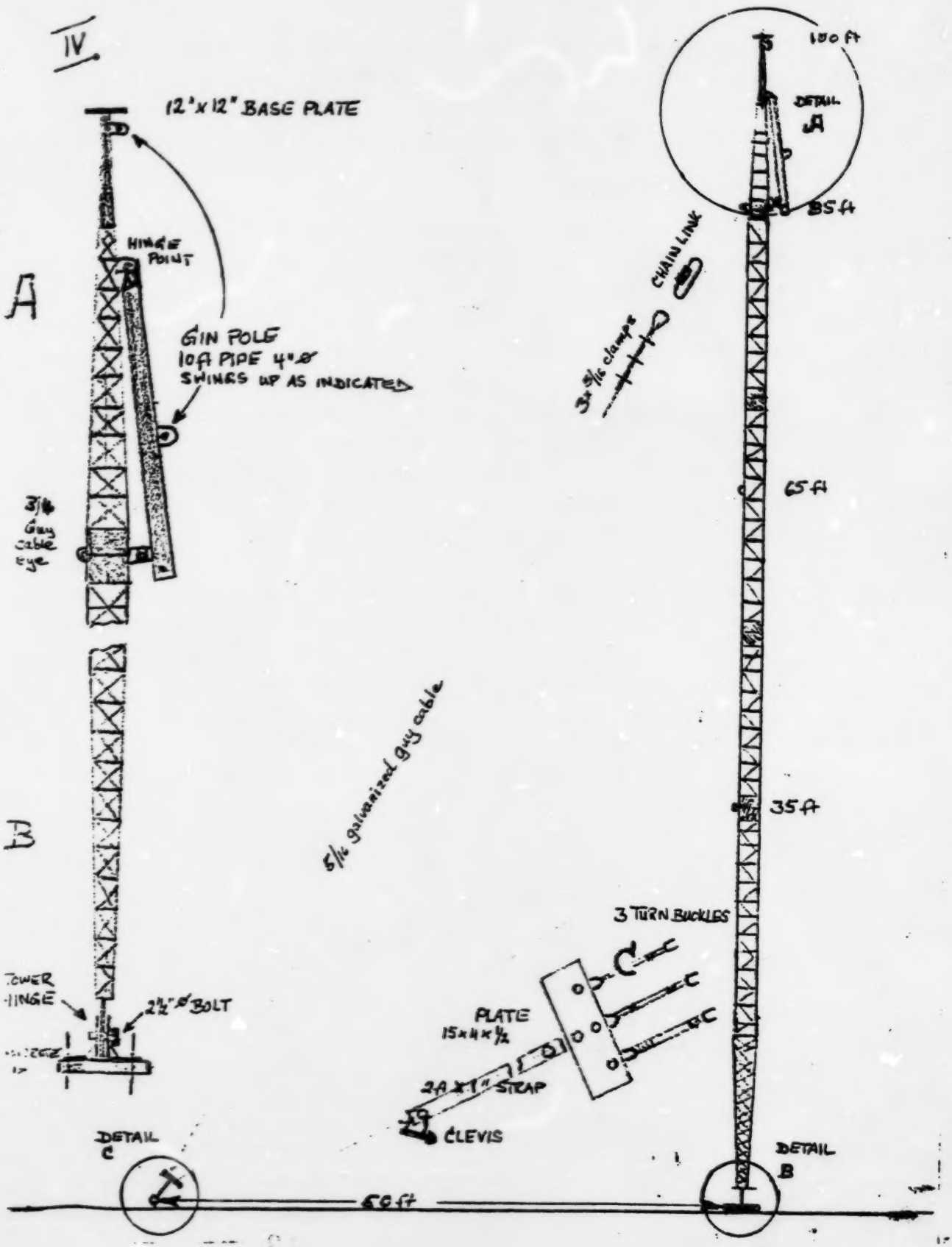
TOWER BASE PLATE

1" STEEL PLATE IN CONCRETE BASE - 4 x ¾" BOLTS WELDED TO STEEL PLATE

45 gls DRUM - CONCRETE REBAR ENFORCED

4" ∅ STEEL PIPE 50" HIGH WELDED ONTO ¾" PLATE

WELDED ONTO 8ft GRADER BLADES


IV
12"x12" BASE PLATE
HINGE POINT
GIN POLE
10ft PIPE 4"ø
SWINGS UP AS INDICATED
3/4 Guy cable eye
A
B
5/16 galvanized guy cable
TOWER HINGE
2½" ø BOLT
DETAIL C
60 ft
100 ft
DETAIL A
85 ft
CHAIN LINK
3x 5/16 clamps
65 ft
35 ft
3 TURN BUCKLES
PLATE 15x4x½
2A x 1" STRAP
CLEVIS
DETAIL B

The battery array consists of approximately 85 1.4 V nominal, 65 Amp/hr (at 8 hr rate) nickel cadminum batteries connected in series to create a nominal 7.7 kwh energy store. Due to the age of the batteries, recovered from surplus, the actual storage capacity is reported to be approximately 5.6 kwh.

The batteries are housed in a separately vented room enclosure in the garage near the house. The insulated room is fitted with a heater to keep the batteries above $0^{\circ}C$.

A schematic of the electrical system installation is given in Figure 2.1.

The operation of the wind generator set in the electrical configuration shown is not straight forward to predict since the system operating conditions represent an equilibrium operating point, balancing a number of parameters including incident wind speed, gear box viscous friction, battery state of charge, applied electrical load, etc.

From a zero speed condition, the generator rotor starts to turn when the torque applied by the wind on the rotor blades exceeds the static friction retarding torque in the bearings and gearbox. Once the generator is in motion a voltage, e, is created at its output terminals proportional to the rotor speed, w. If an electrical load, R, is connected to the terminals an electrical current flows, i. However the flow of current creates a retarding torque or load on the generator tending to slow it down again, reducing e, thereby reducing i, and reducing the retarding torque. Note the "circular" interrelationship. The precise relations are:

i) available power in the wind $P = kpA_r V^3$

where: k = dimensional constant

A_r = rotor swept area

V = wind speed

p = air density

ii) developed voltage $e = NBAW \cos wt = k_i Bw$

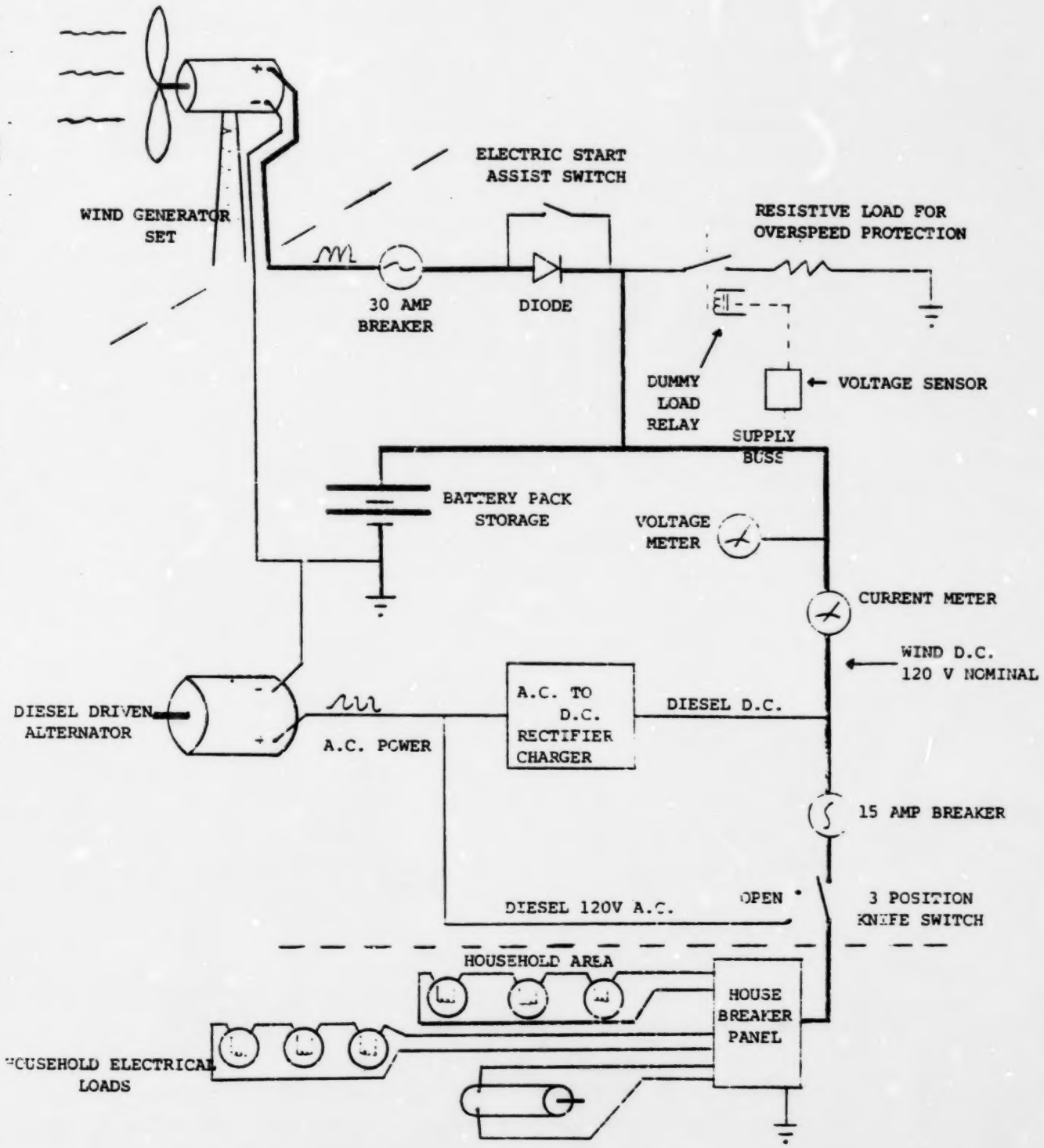
where: e = a sinusoidal function of time

k_i = NA coswt, a parameter relating the physical construction of the generator

B = magnetic field strength in the generator

w = generator rotational speed

FIGURE 2.1 WIND GENERATOR ENERGY CONTROL CIRCUITRY



iii) developed current $i = e/R$ where R = electrical load

iv) developed retarding torque, acting to slow down the generator shaft

$$T_d = k_1 Bi$$

In the present electrical configuration the system operates as follows: if the incident wind speed can create a torque sufficient to over come the mechanical stiction torques the generator and rotor will start to turn. As the rotor speed increases in the incident wind, the applied wind torque decreases and viscous friction retarding torque created by the gear box increases. As long as the applied wind torque exceeds the retarding torque, the generator shaft speed increases. As the speed increases, the generated voltage increases until it exceeds the voltage on the battery pack. At this point the diode begins to conduct, a current flows through the electrical load and an electrical retarding torque is created in the generator. If the electrical load is light and the wind is strong, the generator will continue to speed up, increasing the terminal voltage and the supplied current to charge the batteries or to service the household loads. The generator will cease to speed up when the applied wind torque is balanced by the electrical retarding torque (controlled by load), the viscous friction retarding torque, or by the over speed protection mechanisms.

The diode prevents current flow from the batteries to the generator set, otherwise possible if the generator terminal voltage (a light wind or calm) is less than the battery voltage. To aid in starting the rotor in a marginal wind, an "electric start assist" switch can be closed to defeat the diode and cause the generator to act as a motor to turn the rotor assembly by passing current from the battery pack to the generator. Once the unit is in motion, the switch is opened and the wind may be able to sustain motion of the rotor.

A 10 kw Lister diesel electricity generation plant is available to provide electrical energy to supplement the wind generated supply. Normally one day per week the diesel plant is operated to provide A.C. power to operate the domestic washer/dryer facilities, pump a weeks supply of water from the lake to the holding tank, and perform other energy intensive activities. During these periods the D.C. power system is decoupled from the house and the A.C. diesel power is connected by adjusting the position of the three position knife switch.

The diesel power plant can also be used to recharge the batteries, if the wind generator has not provided sufficient energy to do so. (It is more cost effective to briefly run the diesel generator to recharge the batteries, and live from battery power all week, than to have the diesel plant operate at "idle" speed all week). D.C. energy is converted from the A.C. diesel plant by a Selenium brand rectifier/charger unit.

The physical integrity of the wind generator set and the battery system is partly protected by two safety features; an electrical "dummy" load, and a mechanical rotor overspeed "governor".

At wind speeds above the design speed, the complete generator rotor assembly tends to tilt in a yoke about a horizontal axis to raise the assembly upward, to place the plane of the rotor swept area parallel to the ground. The direction vane does not move and serves to continue to face the yoke toward the wind. The speed at which cut out occurs is set by means of a counter weight, suspended on a cable hanging down through the tower to ground level. The cable can be pulled manually and anchored to manually take the wind generator set out of service.

The generated voltage by the wind turbine is sensed electrically as a measure of rotor speed. If the speed exceeds the prescribed limit a relay is closed to introduce an additional or"dummy" resistance load to the system to cause the generator current to increase, thereby causing an increase in electrical retarding torque and a drop in rotor speed. The relay has hysteresis to prevent switching instability or chattering. The dummy load is simply a 1.6 kw baseboard electric heater, located adjacent to the electrical panel in the garage.

The application of a dummy load also supplies some protection against battery over charging. However, in this case, the dummy load is not large enough to consume all wind generated energy possible, 3 kw, and over charging can still occur if the whole operation is not personally supervised. If the batteries are fully charged, their internal resistances increase causing a drop in charging current, a drop in electrical retarding

torque in the generator, an increase in rotor speed, and thus an increase in applied voltage (to partly re-establish the battery charging current and create an overcharge condition). The voltage detector used to sense the increased voltage and switch in the dummy load thus serves to depress the charging voltage and guard against overcharging.

3.0 COST ANALYSIS

The analysis of capital and operating costs of this installation must be considered with caution. The actual capital costs reported by Mr. Brandt are itemized in Table 3.1. The costs make no provision for the cost of Mr. Brandt's labour in most cases, or the labour of others, obtained on a barter basis. Many components and materials were obtained free by scavenging, or for the scrap price of the equipment. Shipping costs were saved in some cases due to Mr. Brandt's affiliation with NWT Airways. Miscellaneous items purchased may not have been allocated to the project.

The amount of energy created annually by the wind generator set has not been metered. Mr. Brandt felt that the actual diesel fuel quantity savings are more or less equal to the fuel quantity, originally projected. The fuel saving was not defined in the proposal, but was later posted in the CREDA project summary as 4,250 litres per year. However, a discrepancy is evident since a 10 kw Lister diesel generator typically can produce energy under light loads at the rate of 1.9 - 2.4 kwh/litre (ref. local distributor) and the indicated fuel saving represents 8075 - 10,200 kwh/annum of energy consumption. The total annual energy budget for the home assembled in the original proposal was 1532 kwh, including clothes washing/drying and drinking water pumping, see Table 3.2.

For the purposes of this review we have assumed that the original energy budget is correct and that as indicated by the owner, the wind generator can provide energy to sustain all loads except the once per week washer/dryer/water pump/miscellaneous energy demand totalling 477.5 kwh.

The costs to operate the wind generator set are estimated, in the spirit of the owner, to be roughly $100.00 per year. This provides allowance for the occasional burned out relay, gear box oil change, etc., but no charge for labour.

TABLE 3.1 REPORTED CAPITAL COSTS FOR WIND GENERATOR PROJECT

Generator and turbine in one unit from Wellington Wind Power	$ 5100.00
4 Tower sections for scrap value 15 ft.	100.00
Steel for 2 tower sections @ 20 ft. along with assorted material, welding gas, etc.	884.63
Cost of labour to weld the sections	1000.00
Assorted hardware	158.99
Power transmission cable, 250 ft.	583.00
Contracting of one back hoe for 2 hrs.	115.00
Guy cables and turnbuckles	588.67
Transport cost for wind generator	233.79
Purchase of one used set of stationary batteries	150.00
Purchase of 500 board ft. of 2nd grade lumber	100.00
One propane wall heater, Canad, Propane	375.00
asscciated copper and hardware	30.00
Two long destance calls to Wellington	25.00
Contracting of a hydraulic crane	760.00
TOTAL	$10204.00

TABLE 3.2 BRANDT RESIDENCE ENERGY BUDGET

- From original by R. Brandt - July 10, 1981
- * Corrected from original

PART A WINTER SEASON

240 Days

	TYPE OF LOAD	WATTS	X	DAILY HOURS	X	# OF DAYS REQUIRED PER SEASON	= kwh/season
1.	Porch Lights	200		2.0		240	96
2.	Dining Room	100		4.0		240	96
3.	Living Room	150		7.0		240	252
4.	Kitchen	100		10.0		240	240
5.	Master Bedroom	60		2.0		240	28.8
6.	Child Bedroom	60		0.5		240	7.2
7.	Hall *	120		4.0		240	115.2
8.	Bathroom	100		4.0		240	96
9.	Furnace Fan	500		.5		240	60
10.	Propane Clothes Dryer	500		1.8		240/7	27.8
11.	Washing Machine	500		1.8		240/7	27.8
12.	Water Line Heat Tape	1320		1.8		240/14	40.8
13.	Miscellaneous	1000		7.0		240/7	240
14.	Water Pump *	1500		1.0		240/14	25.7
						SUB TOTAL	1353.3 kwh

PART B SUMMER SEASON

125 DAYS

1.	Lighting *	200		1.5		125	37.5
2.	Washing Machine	500		1.8		125/7	16.1
3.	Miscellaneous	1000		7.0		125/7	125
						SUB TOTAL	178.6 kwh
						TOTAL ANNUAL ENERGY BUDGET	1531.9 kwh

The costs to operate the 10 kw Lister diesel generator without the benefit of an energy storage medium (battery pack) are largely based on the hours in service in this case, and not on the total required energy production of 1532 - 477.5 = 1054.5 kwh. Assuming that electrical service is required for 16 hrs/day x 240 days, plus 3 hrs/day x 125 days, or 4215 hrs per year, and that the equipment is basically idling the whole time, the annual diesel generation operating costs to provide the 1054.5 kwh of needed energy are assembled below:

a) fuel cost

4215/hrs/yr. x .7 litre/hr idle fuel consumption x $0.45/litre = $1328.00

b) 8 oil changes per year @ $30.00 240.00

c) annual maintenance and repairs allow 1000.00

TOTAL $2568.00

The fuel consumed is estimated to be 2950 litres. If the diesel generator set was instead operated to charge batteries, the total 1054.5 kwh could be generated by the 10 kw unit in a little more than seven days of operation per season. Suppose that the present battery storage capacity (5.5-5.6 kwh) exists, and the units have a 66% charging efficiency. Therefore, the 10 kw unit must operate 5.5/10 x 1/.66 = .83 hrs to charge the battery pack. A total of 1054.5 ÷ 5.5 = 192 charging operations would be required over the year, suggesting a total diesel running time of 159 hrs. per year. The costs to operate the diesel plant under full load for 159 hours are:

a) fuel costs

159 hrs x 4.5 litres/hr full load fuel consumption x $0.45/litre = $ 322.00

b) 2 oil changes per year per $30.00 60.00

c) annual maintenance and repairs allow 200.00

TOTAL $582.00

Therefore, according to this analysis the operation of the wind generator and battery pack results in savings of 2568 - 100 =$2468 per year. However, the operation of the battery pack alone, to improve the utilization of a diesel generator, would save 2568 - 582 = $1986 per year.

The exact rates here may be subject to some adjustment. However, the fact that a major portion of the cost savings realized by this installation may be due to the presence of battery storage alone, should be recognized.

The simple economic payback on the investment made is suggested by this analysis to be $10,204 ÷ $2,468 = 4.1 years. This payback could be much slower, if it was not for the commendable ingenuity of Mr. Brandt to assemble the system on a shoe string budget.

4.0 PROJECT EXPERIENCES AND PROBLEMS

A considerable amount of experience has been gained in the operation of a wind generator - charging system. A broad variety of problems were found, and many solved. The following paragraphs outline some of these experiences, as assembled from conversation with Roland Brandt and from notes and status reports previously submitted.

1. The Wellington model Black-2 three kw generator

The unit has proven to be a ruggedly constructed unit able to with stand high winds. The tilt upward type of over speed protection mechanism has proven satisfactory. The starting speed of the unit of 15-20 kw/hr. is somewhat higher than desired in view of the limited electrical storage on hand. The stiction and viscous friction present in the speed increasing gear box has contributed to the starting threshold. Instrument oil has been used in place of regular lube oil to improve generator starting characteristics slightly.

2. Generator Installation and Maintenance

Special provisions were made to improve the serviceability of the generator on the mast. A gin pole, hinged a few feet below the mast head, is used as an aid to raise the complete unit into position. Special purpose slings have been constructed to raise individual rotor blades, tools, etc. An attachable 8"x18" working platform has been constructed to provide a secure standing position from which to service the generator. A restraining belt is used to secure the climber while working on the tower.

3. Energy Storage

The present 50 amp/hr 120 volt storage system is felt to be too small to be an effective match to the generation energy available from the wind generator. A 450 amp hour storage system is planned for the future to capture more of the available energy.

4. Radio Noise

Radio frequency interference is created by the arcing and sparking present on the generator communtator. Some attempt to apply arc suppression techniques such as capacitor filtering has met with limited success. The use of an alternator (producing A.C. power) instead of a generator would eliminate the commutator and the attendant interference.

5. Electrical Switch Burn-out

D.C. energy will cause most devices, constructed only for A.C. operation to fail. Resistive devices such as resistive heaters or filament incandescant lamps are not affected. Power and hand tools fitted with universal motors run equally well on A.C. or D.C. Switches can be a problem. Heavy duty positive throw switches have been found to be acceptable. Contact burnout and failure of switches in appliances and hand tools can occur after only a few operations of the switch. In some cases, the switches were secured "on", and the appliance is switched by means of the main breaker panel circuit breaker.

6. House Insurance and property insurance has proven somewhat difficult to obtain due to the mixture of A.C. and D.C., and possibly due to the unique nature of the installation.

7. Azimuth Slip Rings

The slip ring assembly used to pass electricity from the generator, free to move in azimuth, to the stationary tower, was plagued with water collection and icing problems. An improved outer housing was constructed to eliminate the intermittent open circuit faults created.

8. Segregate A.C. and D.C. Circuits

Experience suggests that separate breaker panels and circuits should be installed to carry each of the two forms of energy. The danger of having an A.C. device left plugged into a wall socket that has been resupplied with D.C., is avoided.

9. Start of a Wind Power Generation Project

It is usually suggested that the first step of a wind power generation project is to conduct a wind survey at the site for a period, using an anemometer and recording equipment. Roland suggests a more enlightning approach is to purchase a small wind generator instead and commence by gathering energy and learning the dynamics of the generator equipment. A feeling for the amount of energy available will come from the operating experience on the site.

5.0 EFFECTIVENESS AS A DEMONSTRATION

An important benefit of projects funded by CREDA is their calue as a demonstration of fossil fuel energy conserving technology to the public or the business community.

The project was a good investment for the NWT CREDA program in the sense that first hand experience with wind technology, albeit on a small scale, has been gained in the region, for the education of, and possible future planning by regional government and local conservationalists. There individuals now have a reasonable and applicable reference to turn to when considering future programs for the support or use of wind energy. The $5,100.00 grant was certainly well spent on the enterprising and zealous Roland Brandt. Through his ingenuity, and dedication to the success of the demonstration, far more was accomplished to create a working wind energy generation system than otherwise possible. Unfortunately the interest generated by the project has been minimal. The CREDA office and Mr. Brandt have entertained very few enquiries and no actual site visitors to the project. A few personal friends have taken some interest in the installation but none appear about to undertake a project on their own. The project site is isolated from the community of Yellowknife by a 45 minute journey partway over a barely passable 4 wheel drive trail. While the site is perfect for the lifestyle sought by the Brandt family, the site is not conducive to public demonstration and can only be found with careful and explicit instructions to guide the travellor.

The extremely limited budget available for the project has caused the installation to be very simple, and manually operated and supervised for the most part. As such, the project could only be duplicated in its present form by individuals with equal dedication, interest, and ingenuity to the Brandt family. Consequently, replication of this residential scale wind energy system by others is expected to be low.

In an alternative form, where the installation is more completely automated i.e. battery and generator systems have complete safety controls, power can be taken from a back up source without operator decision, etc. the concept may have a broader appeal. A system able to deliver surplus energy to the regional electrical grid, and draw from the grid as necessary

would have wider appeal also (ignoring the ramifications to the utility company).

6.0 ASSESSMENT OF THE PROJECT

A wind energy generation project similiar to the one examined can be undertaken by someone who is prepared to make the intellectual committment to become familiar with the physical processes and the operation and maintenance of instrumentation and the equipment that make-up a wind energy generation system. The facility must be treated as a project, hobby, or vocational endeavor where the rewards are less economic and more personal satisfaction. There is no doubt that the system has provided social benefits in the form of satisfaction, pride and pleasure to the Brandt family. The project has sensitized the children to the value and aesthetics of the wind as a renewable resource, and has developed a conserving attitude toward energy use. However, the project when viewed against the mainstream of CREDA objectives will cause no impact on fossil fuel use in the NWT. The grant of $5,100.00 was likely a token of encouragement only, since the combined finanical resources of CREDA and the owner were insufficient to purchase or even scrounge a system with sufficient energy storage or controls, no funds were available to allow for changes, experimentation, or upgrading of the facility based on operating experiences. No information transfer program of substance was conceived or funded.

An effective demonstration and assessment of wind energy technology for remote use in the NWT could have sensibly been conducted on a budget of $25 - $30,000.00. Extra expenditures could have been made to purchase suitable energy storage, develop effective generator speed and battery charging controls, and quantitatively monitor the project, and promote the demonstration.

Roland Brandt is thoroughly familiar with the generation system and understands the dynamics of the operation fairly well. Our assessment can make little contribution to improve the operation of the system beyond the short comings already recognized by the owner. The following comments are offered however to assist in considering future modifications planned by the owner:

1. Use of an alternator for electrical energy production.

We agree that an alternator, producing A.C. energy may solve the radio interference problem now experienced. Ensure that the inverter presently in use is not the source of the noise, and beware that most less expensive inverters produce square waves, and not sine waves. Some A.C. circuitry specifically requires sinusoidal A.C., and can be destroyed by square wave power.

Contrary to belief, the magnetic field in the present generator, created by an internal permanent magnet, is not a source of restraining torque when the rotor is stationary and does not act to increase the generator's starting threshold. No magnetic field related retarding torque is created until current actually flows to a connected load. This condition only occurs after the generator speed has increased to the point that its terminal voltage exceeds the battery pack voltage and the charging circuit diode begins to conduct.

2. Changing the wind generator's starting threshold

The problem of recovering a high proportion of the available wind energy with varying wind speeds is the classical wind energy system design problem. As a result of mechanical limitations and the characteristics inherent in electrical generation equipment conversion of wind energy to electrical energy can only occur efficiently over a power range of 10 to 1 - or a rotor speed range of about 2.2 to 1. The top end of the efficient range is often set near the unit design speed, which is in turn often set at 1.7 times the average wind speeds for the site. Within limits, the recovery of available wind energy can be increased by raising the design speed, since the gains at high wind speed will outweigh the energy missed at the low speed end due to the increased cut in speed. However, the increased recovery will be accompanied by a drop in the average operating hours of the generator, and will require an increase in storage capacity to hold the energy for use over longer lulls.

3. Increase in Energy Storage Capacity

We agree with Mr. Brandt's assessment that the energy storage capacity of the system should be increased. In view of the above comments on starting threshold, the economically optional amount of capacity should be carefully established based on load profiles, generator size, actual wind statistics and starting threshold.

If battery capacity is to be purchased at off the shelf prices, reports indicate that lead-antimony cells have the lowest life cycle cost of the types usually sought of this application.

4. Safety Systems

A slightly more sophisticated over voltage and overspeed protection system is being considered. It is agreed that the overvoltage protection system should be capable to sink the full 3.0 kw+ power generating capacity of the system - and not simply the existing 1.6 kw "dummy load". Human error presently can permit the batteries to be damaged by overcharging.

5. Use of an Inverter

AC energy may be created to run washing machines, etc. from the present DC wind energy by employing an inverter. There are three general types of inverters, having distinctly different qualities. Rotary inverters use small DC motors to run AC generators. These inverters have many moving parts, so they are theoretically more prone to breakdowns than other inverters. They also tend to be less efficient, losing a lot of power in the process of converting DC to AC. On the other hand, they produce a true AC current, they are the cheapest variety of inverter available, and they are more fully time-tested than newer varieties of inverter. A well-made rotary inverter should last a long time. Reed type inverters have only one moving part, the reed, which vibrates in response to the DC power. Through its vibrations, it creates a sort of pseudo-AC current, switching rapidly from positive to negative pulses as the reed moves left and right. Inverters of

this type should suffer few breakdowns, but the current they provide is insufficient for delicate AC equipment, such as stereos. Solid state inverters presently have a reputation for a high failure rate, but they hold the greatest promise for the future. When perfected, they should be the most reliable inverters, because they have no moving parts at all - they're wholly electronic. They produce a pseudo-AC current, but the best models can simulate AC so well that electric equipment won't know the difference.

BUREAU 123 — ref 10c:vv226:rv2 REF 102.00228.F02

BEGAN JAN 1955 2204100 YELLOWKNIFE A — DEBUT JAN 1955 2204100 YELLOWKNIFE A — NWT TN-O

MEAN WIND SPEED IN KILOMETRES PER HOUR (16 POINTS)
VITESSE MOYENNE DU VENT EN KILOMETRES PAR HEURE (16 DIRECTIONS)

YEAR	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEP	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUELLE	YEAR ANNEE
1955	13.1	16.6	16.8	18.6	17.1	16.8	17.8	14.3	20.3	14.4	16.9	14.9	16.1	1955
1956	12.9	14.7	14.8	18.4	18.0	18.8	16.4	15.6	18.2	14.9	16.0	15.6	15.8	1956
1957	16.1	19.4	16.7	16.0	18.9	19.3	17.8	16.7	22.5	20.3	20.0	15.8	17.5	1957
1958	14.2	10.9	14.8	17.7	17.2	18.8	15.3	14.0	14.2	19.0	17.4	12.2	15.2	1958
1959	17.2	12.9	14.9	17.0	18.5	18.3	18.4	16.3	19.0	15.6	12.2	12.2	15.8	1959
1960	14.4	13.5	15.4	18.5	17.6	17.9	17.8	17.1	20.0	19.2	17.2	15.0	17.8	1960
MEAN	14.8	14.2	15.2	18.1	17.9	18.5	17.4	16.3	19.0	18.2	16.4	13.9	16.8	MOYENNE
1961	14.2	13.2	15.2	17.2	18.1	18.9	18.4	16.6	19.0	19.3	15.8	13.2	16.6	1961
1962	17.6	14.0	15.4	17.6	16.4	18.4	18.8	15.7	17.5	16.7	16.8	14.3	16.8	1962
1963	18.6	12.7	13.9	17.6	19.2	17.4	17.8	15.7	17.7	18.9	17.9	10.1	16.2	1963
1964	9.6	10.7	12.9	16.2	15.6	16.3	14.8	15.2	13.6	16.1	15.0	13.3	14.1	1964
1965	14.7	11.0	13.2	16.8	16.0	16.8	15.2	14.2	16.4	16.4	14.9	13.3	15.1	1965
1966	12.3	13.8	13.7	16.7	20.1	16.8	16.2	16.7	16.4	19.0	13.2	12.1	15.9	1966
1967	10.6	13.7	13.7	15.3	16.9	17.7	16.5	16.7	15.9	17.5	15.2	12.2	15.9	1967
1968	12.3	14.0	13.7	15.3	16.6	17.1	17.2	15.8	17.5	17.6	15.2	11.9	15.9	1968
1969	13.3	13.7	12.8	15.3	16.6	17.5	17.7	15.8	16.2	16.9	13.1	12.1	15.2	1969
1970	14.7	13.3	13.9	14.6	17.5	18.2	15.1	14.7	16.2	15.6	13.1	12.3	14.9	1970
MEAN	13.8	13.0	13.6	16.4	17.1	17.6	16.8	15.2	16.2	16.7	13.6	12.1	15.6	MOYENNE
1971	16.0	14.0	14.8	16.6	18.9	15.8	15.5	15.1	19.1	16.0	13.3	11.2	15.5	1971
1972	14.0	13.8	14.8	18.0	15.1	16.8	14.3	13.4	15.5	16.9	14.8	10.6	14.9	1972
1973	13.0	13.5	15.8	18.4	18.0	18.2	16.7	14.3	16.1	15.0	12.7	12.0	15.0	1973
1974	15.0	14.5	16.7	17.2	17.6	18.2	17.7	15.0	16.8	19.7	14.8	14.2	16.4	1974
1975	13.0	13.9	14.7	14.7	17.6	15.8	14.9	14.0	14.9	15.7	13.5	12.3	14.4	1975
1976	12.0	11.9	13.6	14.4	16.8	14.7	13.8	12.6	12.9	16.6	14.8	12.3	13.8	1976
1977	10.1	12.4	13.2	14.4	16.7	16.4	13.5	13.8	12.0	14.6	15.5	10.1	13.7	1977
1978	11.2	10.9	13.1	15.6	15.6	16.0	14.7	14.6	15.0	16.7	12.4	10.0	13.9	1978
1979	11.9	11.0	12.7	15.6	15.3	15.7	14.4	14.6	14.0	15.4	13.1	14.3	13.7	1979
1980	11.7	13.7	12.9	15.4	15.7	14.4	13.5	12.0	15.5	16.0	16.9	11.3	14.1	1980
MEAN	12.8	13.3	14.2	15.9	16.9	16.0	14.6	14.3	15.2	16.3	14.2	11.7	14.8	MOYENNE

PERIOD OF RECORD/PERIODE DES RELEVES

MEAN	13.7	13.5	14.7	16.6	17.0	17.2	16.1	15.6	16.6	17.0	15.2	13.1	15.6	MOYENNE
STN.DEV.	2.4	2.3	1.7	1.6	1.5	1.5	1.8	1.8	2.5	1.9	2.1	2.8	1.3	ECART-TYPE
# OF YEARS	26	26	26	26	26	26	26	26	26	26	26	26		DUREE ANNEES

PERCENTILES														PERCENTILES
95% <	18.4	18.5	18.5	19.4	19.8	19.3	18.7	19.5	21.7	20.2	19.3	18.5	18.8	95%
75% <	15.8	14.1	15.7	17.9	18.0	18.3	17.8	16.7	18.5	19.4	16.9	15.6	16.7	75%
50% <	13.5	13.7	14.9	16.5	17.8	17.5	16.4	15.7	16.3	16.8	15.1	12.6	15.5	50%
25% <	12.0	12.6	13.2	15.4	15.7	16.2	14.6	14.5	14.8	15.6	13.3	11.3	14.3	25%
5% <	9.8	8.2	12.0	13.9	14.4	13.9	12.8	12.2	12.3	13.6	11.9	9.9	13.6	5%

CODE 2

NORMALS/NORMALES 1955-80

CODE 2

MEAN	13.7	13.5	14.7	16.6	17.0	17.2	16.1	15.6	16.6	17.0	15.2	13.1	15.6	MOYENNE
STN.DEV.	2.4	2.3	1.7	1.6	1.5	1.5	1.8	1.8	2.5	1.9	2.1	2.8	1.3	ECART-TYPE
# OF YEARS	26	26	26	26	26	26	26	26	26	26	26	26		DUREE ANNEES
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
	JAN	FEV	MARS	AVR	MAI	JUIN	JUIL	AOUT	SEP	OCT	NOV	DEC	ANNUELLE	

TABLE 124 REF 102.00228.E04 BEGAN JAN 1955 2204|00 YELLOWKNIFE A NWT
TABLEAU 124 REF 102.00228.E04 DEBUT JAN 1955 2204|00 YELLOWKNIFE A TN-O

PREVAILING WIND DIRECTION (16 POINTS)
DIRECTION DE VENT DOMINANT (16 DIRECTIONS)

YEAR	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEP	OCT OCT	NOV NOV	DEC DEC	ANNUAL ANNUELLE	
1956	E	NW	NE	E	SSE	SSE	SE	NW	NW	N	NW	NW	E	1956
1957	NE	NW	E	N	NE	E	SE	E	E	N	NW	W	E	1957
1958	W	NW	NE	N	E	NW	N	E	NW	E	NW	E	E	1958
1959	E	NW	E	ENE	E	E	E	E	NW	E	E	E	E	1959
1960	NW	E	NE	NW	E	NE	E	NE	E	NW	NW	NW	NW	1960
PREVAILING	NW	NW	NE	E	E	SSE	NW	SSE	NW	N	NE	E	E	PREVAILING
1961	E	NW	NE	NW	E	SSE	S	S	SE	E	NW	NW	E	1961
1962	NW	E	NE	NE	NE	NE	E	E	NW	E	E	NW	E	1962
1963	NW	E	NE	SSE	SSE	E	E	E	E	NW	E	NW	E	1963
1964	E	ENE	NW	ENE	ENE	SSE	SSE	ESE	NNW	NNW	NW	WNW	ENE	1964
1965	WNW	NW	NW	SSE	SSE	SSE	E	E	N	E	NE	E	E	1965
1966	NE	NW	E	NNE	ESE	E	SSE	SSE	E	E	E	E	E	1966
1967	E	E	N	E	E	E	E	S	S	SE	N	N	E	1967
1968	E	N	E	NE	NE	E	E	E	N	E	N	N	E	1968
1969	NW	E	E	E	E	E	SSE	E	E	E	E	ESE	E	1969
1970	NW	NW	E	E	ENE	S	S	SE	E	E	NNW	E	E	1970
PREVAILING	NW	E	E	E	S	S	S	S	E	E	E	E	NW	PREVAILING
1971	NW	E	E	SSE	E	E	S	SSE	NNW	SSE	E	NW	E	1971
1972	NW	NW	E	E	E	E	E	S	E	NW	ESE	E	E	1972
1973	E	ENE	E	E	E	E	E	S	SE	E	E	E	E	1973
1974	WNW	E	NW	NNE	N	SSE	SSE	NNW	WNW	E	E	E	E	1974
1975	W	E	ENE	E	S	ENE	SSE	N	SSE	E	NE	E	E	1975
1976	NW	NNE	E	E	SSE	S	S	E	E	SSE	ESE	E	E	1976
1977	NW	E	E	SSE	E	SSE	E	N	SSE	N	ENE	NW	E	1977
1978	E	SE	ENE	N	NNE	E	N	SSE	E	E	E	NW	E	1978
1979	NW	NW	NNE	NNE	ENE	S	S	SSE	E	E	E	NW	E	1979
1980	E	N	E	E	SSE	E	SSE	N	ESE	ESE	E	NW	E	1980
PREVAILING	NW	E	E	E	SSE	S	S	S	E	E	E	E	ENE	PREVAILING
OF YEARS	26	26	26	26	26	26	26	26	26	26	26	26		DUREE ANNEES

PERIOD OF RECORD/PERIODE DES RELEVES

PREVAILING DIRECTIONS

														DIRECTIONS DOMINANTES
FIRST	NW	E	E	E	E	S	S	S	E	E	E	E	E	PREMIERE
SECOND	E	NW	NE	NE	S	SSE	SSE	SSE	NW	ESE	NW	NW	NW	DEUXIEME
THIRD	NNW	NE	ENE	N	SSE	E	E	N	ESE	NW	N	NE	NE	TROISIEME
FOURTH	N	ENE	NW	ENE	NE	NE	NE	E	SE	N	ESE	ENE	N	QUATRIEME
FIFTH	ENE	N	N	SE	ENE	ENE	NE	NW	SSE	SE	NE	N	ENE	CINQUIEME

CODE 2 NORMALS/NORMALES 1955-80 CODE 2

PREVAILING	NW	E	E	E	E	S	S	S	E	E	E	E	E	DOMINANTE
OF YEARS	26	26	26	26	26	26	26	26	26	26	26	26		DUREE ANNEES
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
	JAN	FEV	MARS	AVR	MAI	JUIN	JUIL	AOUT	SEP	OCT	NOV	DEC	ANNUELLE	

WIND VENT

STATION YELLOWKNIFE A

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.
HOURS	744	672	744	720	744	720	744	744	720
PREVAILING DIRECTION	WNW	NW	NW	E	NNE	SSE	SSE	SSE	SSE
MEAN SPEED	8.9	13.5	11.9	14.2	13.8	12.6	12.4	12.4	14.0
MAXIMUM HOURLY WIND									
Speed km/h	37	50	32	46	33	32	35	33	39
Direction	NNW	NNW	N	N	NNE	WNW	E	NNW	N
Date	14‡	06	23‡	08	03‡	18	02	25‡	11
PEAK SPEED									
Speed km/h	46	82	44	52	44	37	48	44	54
Direction	NNW	NNW	E	ENE	ENE	NNW	NNW	NW	N
Date	14	05	26	14	01‡	22	19	22	11
SPEED CLASSES (%) km/h									
Calm	22	6	4	3	4	2	3	2	2
1-5	13	5	5	3	5	6	5	5	7
6-11	34	38	48	36	36	42	47	43	34
12-19	23	33	29	36	32	36	29	37	34
20-28	6	13	13	19	20	13	13	12	20
29-38	2	3	1	2	3	1	3	1	3
39-49		2		1					+
50-61		+							
61									
AVERAGE SPEED IN km/h									
PERCENTAGE FREQUENCY OF DIRECTION									
N	7.2	11.4	10.8	14.6	17.0	15.0	15.3	16.7	16.9
	3	5	8	7	11	8	5	5	9
NNE	5.5	6.4	8.3	12.3	15.2	11.9	11.6	9.5	12.7
	1	2	4	6	14	6	5	2	8
NE	5.7	5.9	9.9	14.5	16.0	12.6	13.3	11.3	16.0
	3	2	4	11	9	5	8	7	10
ENE	6.3	8.5	11.8	17.5	17.1	11.8	13.2	12.1	12.8
	2	3	4	13	9	5	8	6	7
E	12.3	14.5	17.8	15.3	13.7	12.3	13.2	10.2	14.3
	9	9	9	17	12	9	10	6	12
ESE	10.3	15.3	12.9	12.8	13.6	10.8	11.9	10.2	13.3
	3	4	4	7	5	8	5	4	6
SE	7.8	11.0	11.3	14.1	12.2	11.9	9.2	11.0	10.8
	3	2	4	4	5	8	6	8	6
SSE	5.1	8.7	12.5	12.3	11.3	13.0	11.4	12.3	13.7
	1	1	9	7	7	17	11	17	12
S	5.6	12.8	10.8	13.3	11.3	13.6	13.4	11.4	14.3
	2	2	4	6	8	9	7	9	5
SSW	6.7	9.8	8.7	11.6	13.2	10.5	11.9	8.0	12.2
	1	1	1	2	3	2	2	3	2
SW	5.0	11.6	5.8	12.7	13.7	8.6	9.6	6.3	7.1
	1	2	1	1	1	1	5	1	1
WSW	5.0	11.0	8.3	13.9	10.9	10.3	9.0	7.6	7.7
	1	4	1	1	1	1	5	2	2
W	11.4	12.6	9.3	14.8	6.5	10.3	8.6	11.1	7.6
	10	8	5	5	1	2	5	4	2
WNW	14.0	12.9	12.1	15.6	11.5	17.4	12.1	14.9	13.0
	19	13	10	2	2	3	3	7	4
NW	13.3	16.5	14.2	15.5	13.8	14.9	16.8	14.1	18.7
	13	23	15	4	4	6	6	7	6
NNW	14.2	19.6	13.1	16.0	17.3	15.2	19.7	19.8	15.0
	6	14	13	4	4	8	6	10	6

Energy, Mines and Resources Canada | Energie, Mines et Ressources Canada

Northwest Territories Public Works

Wind Energy For Remote Living

Post-Project Summary

Canada/Northwest Territories Conservation and Renewable Energy Demonstration Program

Project Location:
Prelude Lake, N.W.T.

Date:

Technology:
Wind Energy

Project Manager:
Roland Brandt,
Box 2924,
Yellowknife, N.W.T.
X1A 2L8

Project Number:
H3.3.8

Sector:
Residential

Status:
Complete

Province:
Northwest Territories

Purpose:
To demonstrate the effectiveness of a wind energy conversion system in replacing a diesel powered generator.

Description:
A 3kW wind generator, mounted on a 100 ft. high tower, replaced a diesel powered generator as the major source of domestic power.

Contributors:

N.W.T./Canada Program	$ 5,100
R. & A. Brandt	$ 5,104
	$10,204

Demonstrated Benefits:
The remote and isolated location of the residence, the high cost of fuel and inefficiency of their diesel system, combined to make wind generated power an attractive source of electrical energy. Wind generated power has produced 250 kWh of power a month for normal electrical requirements. 65 amp hours of Ni-cad storage batteries will store enough energy to provide five kWh of power when the wind is not sufficient to generate electricity.

The dollars spent on this project were minimal primarily because of the ingenuity of the proponent. The average family purchasing components off the shelf should budget considerably more. Much of the equipment used in this project was purchased or salvaged locally thereby reducing the capital cost of purchasing equipment. Costs of operating the wind generator are minimal — an annual oil change of the gear box.

A reduction of 4250 litres of diesel fuel annually at 42.1 per litre will save $1,789.

Further Information:
Although Mr. Brandt considers this installation a success, a qualified experience on continuous operation has not been documented. The capital costs of a bank of new batteries and reliable permanent instrumentation were not included in Mr. Brandt's original capital cost plan.

Information Contact:
Northwest Wind Power,
Roland Brandt,
Box 2924,
Yellowknife, N.W.T.
X1A 2L8
PH: YK Mobile 2M4378

or Energy Conservation Division,
Department of Public Works,
Government of the Northwest Territories
Yellowknife, N.W.T.
X1A 2L9
PH: (403) 873-7203

Project Name:
Wind Energy for Remote Living

Economic Analysis:

Project Costs:	Capital	$ 9,204
	Installation*	$ 1,000
	Total Demonstration Project Cost	$10,204
Operating Costs:	Before conversion	$ 6,367/year
	After conversion	$ 2,346/year
	Payback/2.5 years	$ 4,021

*most of the installation (labour) was provided on volunteer basis.

Monitoring/Evaluation:
Evaluation of the system is in the form of reports submitted by the operator. To date reports have been submitted describing:

1) erection of the tower and installation of the wind energy generator with a breakdown of installation costs; and
2) observations and comments on 24 months of operation.

Technical Details/Specifications:
Electric wind generator: Wellington Windpower,
P.O. Box 15,
Wellington, Ontario, M0K 3L0
Phone: (613) 399-3171

Model: Black 2-3 kW
Wind conditions in the Yellowknife area produce on average 500 watts (291 amps) over a 10 hour period.

Energy in excess of that used by all the small appliances, lights and refrigerator was stored in 65-85 amp/hr. Nickel Cadmium storage cells. An essential element of the system is energy conservation which features:

- gravity water system
- two storey house heated by airtight wood stove
- water reservoir, washer and dryer run by diesel generator
- stove and hot water tank heated by propane

Schematic Diagram: